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MECHANICAL CHARACTERISTICS AND WEAR BEHAVIOR OF HYBRID COMPOSITES WITH ARECA AND NEEM FIBERS

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ABSTRACT

Composite materials usage is found widely in various applications ranging from Sports to Aerospace components substituting glass fibres in many applications. The need for research work on Neem and Areca reinforced composites paves the way for extensive study for the usage of these fibres in composites as reinforcements. This paper will discuss about the fabrication, mechanical characterization of a hybrid composite (Neem + Areca + GFRP). The composite is fabricated using hand lay technique. The arrangement is such that Neem fiber is placed over the Areca fiber. Epoxy resin LY556 and HY951 hardener was used as the binding agent. Glass Fiber composites are used on both the sides in order to improve the surface finish and surface hardness. The volumetric fraction is one third of the total volume occupied by Neem and areca fiber. Test results indicate that hybrid natural composite has excellent properties under impact and hardness test. Failure morphology is done using Scanning Electron Microscope (SEM) and the internal structure of the broken specimen were discussed.

KEYWORDS: Natural Fibers, Areca Fiber, Neem Fiber, Epoxy Resin, Hand-Layup Method, Hybrid Composite, Tensileflexural and Impact Properties. Scanning Electron Microscope & Wear Rate

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Original Article

1. INTRODUCTION

Composite materials volume and number of applications of composite materials have grown steadily and conquering new markets relentlessly. They constitute a significant proportion of products ranging from everyday products to niche applications. Fiber-reinforced composites are Polytrophic in nature thereby tailoring its properties according to the design requirements. This flexibility is used to select a reinforcement in a thereby increasing the stiffness in a specific direction. Such fibres are used for fabricating curved panels eliminating the necessity of secondary forming operation. These fibre reinforced Composite materials produces structures with zero thermal expansion of expansion. Their eco-friendly, biodegradable and cheaper rate makes them superior over many other engineering materials.

Cellulose, hemicelluloses, pectin and lignin are the primary constituents of a natural fibre. The fabrication technique of composites with natural fibers as reinforcements consumes less energy when compared to their synthetic counterparts. [2, 3, 4, 5]. Good composite materials can be fabricated with natural fibers with good mechanical, physical and chemical properties. A secure bonding with matrix is very much desirable [6, 7, 8]. Adhesion between the matrix and the reinforcement plays a crucial role in deciding the mechanical properties like tensile strength of a composite material [9,10,11]. Mechanical properties like tensile, flexural and other properties

of natural fiber based composite materials were evaluated by Vijaya Ramnath et al [12, 13].

Sharavanana et al [14] fabricated hemp and flax composites in the mono and hybrid forms of composites using hand lay-up method. They conducted various mechanical tests to determine the mechanical characteristic of the composite laminate and the results were compared. They concluded that hybrid composites were performing better. Murali et al[15] conducted crash test analysis on natural fiber composite materials and demonstrated the suitability of hemp and jute (mixture) Research is also going on Sandwich composite which is a special form of a laminated composite and basalt fiber composites.[16, 17, 18]

Mohan Kumar [19] studied the mechanical properties of the fibers extracted from areca fruit and compared those properties with the other known natural fibers. He studied the chemical treatment of these fibers. Chikkol et al [20] carried out physical and flexural properties of composites made by areca fibers with a randomly distributed orientation of fibers. The results showed that flexural strength increased with increase in the fiber loading percentage. Compared to untreated fiber, significant change in flexural strength had been observed for treated areca fiber reinforcement. Poddar et al [21] evaluated the Mechanical and Thermal Properties of Short areca nut leaf sheath fibre reinforced polypropylene composites. In this study the composite with 10% areca nut leaf sheath fiber was found be performing better with higher mechanical properties.

Government Rabboni Mike et al [22] examined the effect of filler content and the particle size on the mechanical properties of neem bark flour-filled high density polyethylene composites. Thandavamoorthy et al [23] fabricated composites withch opped neem fibers and bidirectional banyan woven fibers with epoxy resin using hand lay-up technique. Two fibers, namely chopped neem fiber and woven banyan fiber, were stacked in three different sequences. The mechanical properties, such as tensile, compression, and impact tests, were carried out to quantify the effect of the fiber weight fraction and the stacking sequence of fiber on the strength of the hybrid composite. The increase in 9 % woven banyan fiber weight fraction has a positive influence on the tensile and compressive strengths of the natural fiber-reinforced hybrid composites. Shankar ganesh etal [24] conducted experiments with neem and Indian almond fiber based composites and concluded that the presence of neem increased the tensile properties of the composites.

Sweety Shahinur et al [25] stressed the use of Natural Fibres as they are Cost effective, Non-Abrasive and Eco-friendly. The drawbacks of the Natural Fibers was also discussed as they have Uneven properties at different parts. Puglia et al [26] pointed out the drawbacks of using Natural Fibre Composites as they are hygroscopic in nature. The moisture absorption was one of the main drawbacks cited by them.

Yusran et al [27] concerned about the hydrophilic nature of the Natural Fibres as it affected the performance of the composites. At elevated temperatures, the Natural Fibres have a tendency to catch fire. The treatment of Fibres with NaOH was suggested. Donghwan Cho et al [28] concluded that the properties of the polymeric resins were significantly improved by incorporating the natural fibers into the resin matrix.

Nor AmalinaNordin et al [29] compared the specific wear rate between Kenaf Polyester Composite (KPEC) and Kenaf Epoxy Composite (KEC). Chin et al [30] concluded that the presence of certain natural fibers like kneaf increase the wear performance of composite materials.

2. MATERIALS USED

The inexpensive nature, abundant availability of Neem and Areca fibers has a high potential as reinforcing fibers in polymer composites. These fibers are pest resistant and easily extractable, were shown in the figure 1. Epoxy resin (Araldite LY 556) and the hardenerHY951 were used.

3. FABRICATION OF COMPOSITES

In the beginning of the process the fibers are allowed to dry in sunlight to get rid of moisture content. In order to separate them as small flakes, a comb was used. Then the recommended releasing agent (polyvinyl alcohol) was applied for easy removal of the composite. Two epoxy resin coated glass fiber are made and it allowed drying for 7 to 10 hours for curing. Now on the mould the releasing agent is applied and another one of GFRP laminate is placed on it. The Neem and Areca fibres were placed between GFRPs. After that the GFRP laminate was laid to form the top surface. A separator was used to remove composite material from the mould. Then, a 25 kg rectangular iron bar was placed over it. It was persevered for many hours without interruption to allow the resin mixture dry. According to the necessary measurement, the composite is machined. The Sample size is 300 mm× 300 mm×8 mm was prepared. In this work, 3 types of samples were fabricated. They are named as follows:

- **Sample 1**: Neem-75% + Areca-25% by Volume
- **Sample 2**: Neem-50% + Areca-50% by Volume
- **Sample 3**: Neem-25% + Areca-75% by Volume

Figure 1: Areca Plant, Areca Fiber and Neem plant, Neem Fiber.

Figure 2: Shows the Laminates of Samples 1, 2 and 3.

4. TESTING OF COMPOSITE SPECIMENS

4.1 Tensile Test

Tensile testing process was conceded by following the ASTM D638 standard with the speed of 5mm / min in Tinus Olesan UTM. The Sample dimensions are shown in figure 3 and Tensile Tested specimens are shown in figure 4. A minimum of five specimens were tested to get the average value. The UTM setup is shown in figure 5.

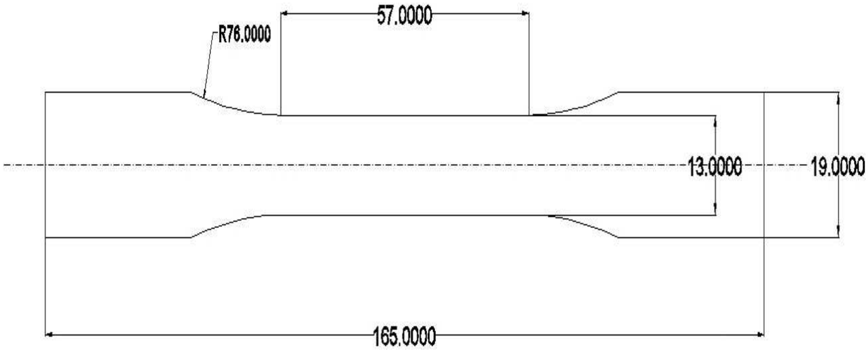


Figure 3: Tensile Test Specimen as per ASTM D: 638.

Figure 4: Tensile Tested Samples.

Figure 5: Tensile Test Machine Set-up (UTM).

4.2 Flexural Test

The flexural test was done by preparing the sample as per ASTM: D790 standard as shown in figure 6 and Flexural tested sample is shown in figure 7. The Flexural Testing is done at room temperature about 40% relative humidity. The Composite experimented to a load at its half way among the chains of fractures and breaks is shown in figure 8.

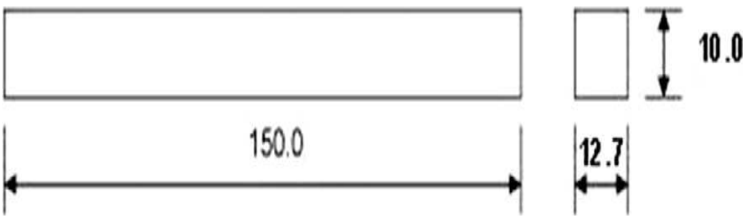


Figure 6: Schematic Diagram of Flexural Test Specimen.

Figure 7: Flexural Tested Specimens.

Figure 8: Flexural Tested Specimen at Failure.

4.3 Impact Test

The different composites have been done to analyze the impact capability, During the Charpy impact test using as shown in figure 10. Test is done by ASTM: D5379 standards as given in figure 9. and the setup is shown in figure 11.

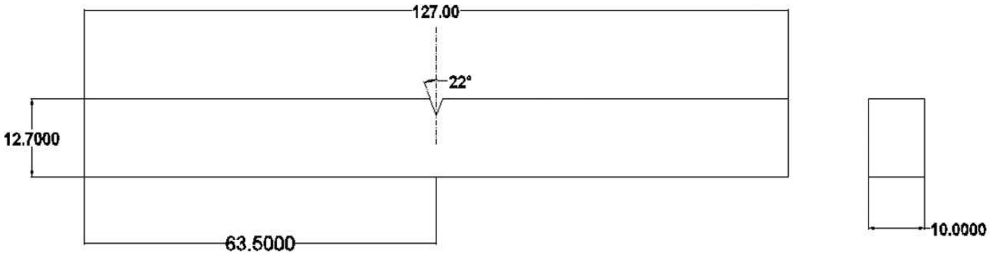


Figure 9: Schematic Diagram of Charpy Test Specimen.

Figure 10 Impact Tested Specimens.

Figure 11: Charpy Test/Impact Test Set Up.

4.4 Wear Test

Tribological behavior of a material is important in the study of its characteristics. Wear test is a laboratory procedure for determining the wear of materials during sliding using a pin-on-disk apparatus as shown in the figure 12. Materials are tested in pairs under nominally non-abrasive conditions. The principal areas of experimental attention in using this type of apparatus to measure wear are described. The coefficient of friction may also be determined. Wear results are usually obtained by conducting a test for a selected sliding distance and for selected values of load and speed.

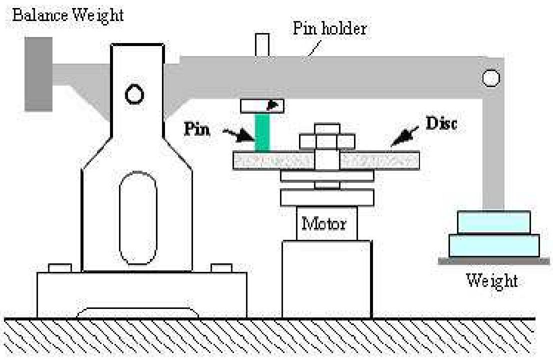


Figure 12: Wear Test Apparatus.

4.5 Morphological Analysis

In this work morphological analysis was performed using Scanning Electron Microscope. The Tescon-300 type machine was used. It can be operated with a Voltage of 0.3-30kV with a magnification up to 4, 00,000. The resolution ranges upto 5 nm with IRCD Camera Chamber view.

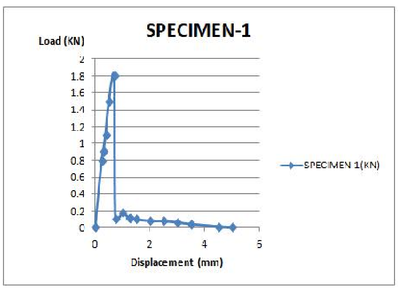
5 RESULTS AND DISCUSSIONS

5.1 Tensile Test

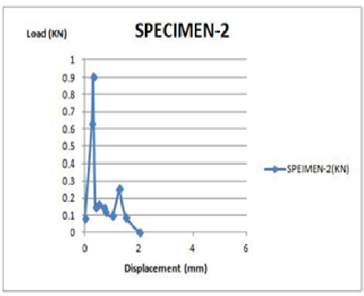
The pulling force applied on the specimen in the UTM was called a load, which was plotted against the material length change, or displacement as shown in the figure 13. The observations were given in the table 1. From the test result, it could be concluded that Specimen1 had an ultimate tensile load of 1.81kN, specimen 2 had 0.91kN and specimen 3 had 2.85 kN. In most of the parameters the specimen three does better in tensile test.

Table 1: Tensile Test Results

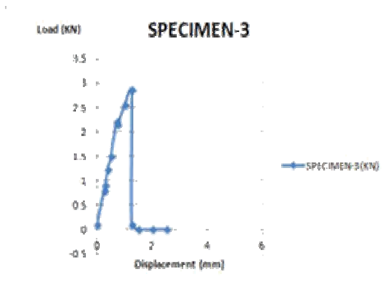
Test Parameters	Observed Values		
	Specimen 1	Specimen 2	Specimen 3
Gauge width (mm)	13.31	13.33	13.25
Gauge thickness (mm)	9.56	7.58	6.56
Original Cross sectional area (mm^2)	127.24	101.04	81.92
Ultimate tensile load (kN)	1.81	0.91	2.85
Ultimate tensile strength (Mpa)	14.00	9.00	23.00



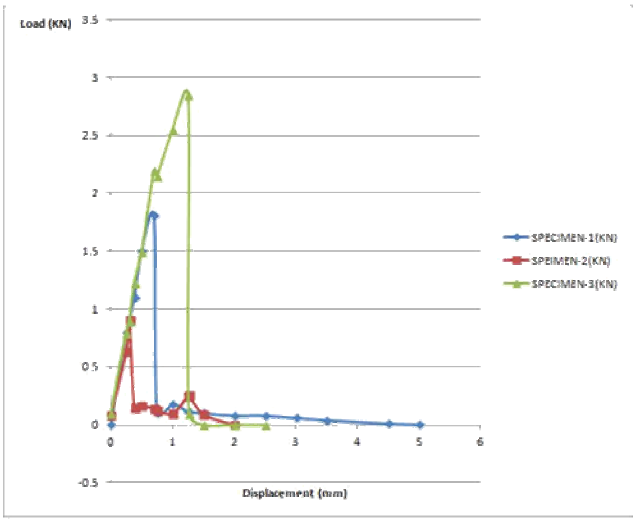
a: Specimen 1



b: Specimen 2



c: Specimen 3



d: Comparison of Specimens 1,2 and 3

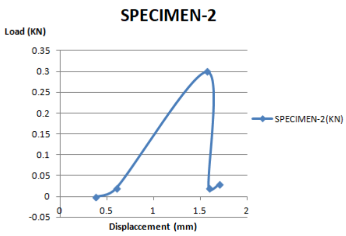
Figure 13: Tensile Test: Displacement Vs Load.

5.2 Flexural Test

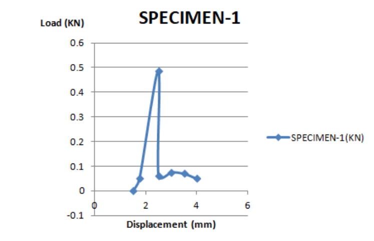
The flexural properties of the composite samples are furnished in table 2. Load Vs displacement graphs were drawn as shown in the figure 14. The specimen 3 performs well in comparison with specimens 1 and 2.

Table 2: Flexural Test Results

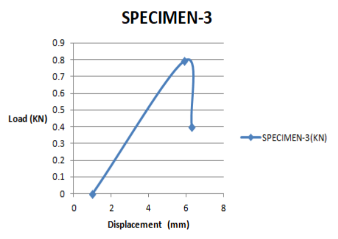
Test Parameters	Observed Values		
	Specimen 1	Specimen 2	Specimen 3
Flexural Strength (Mpa)	23.57	24.09	91.11



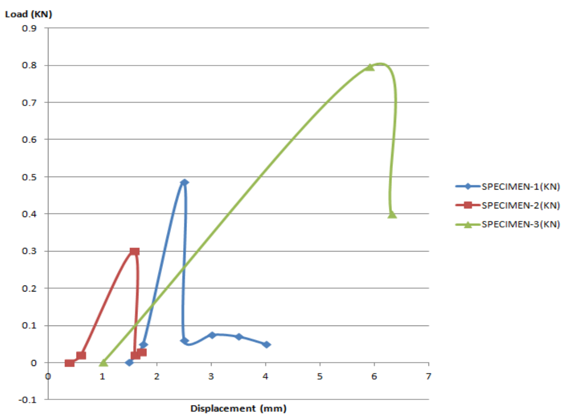
a: Specimen 1



b: Specimen 2



c: Specimen 3



d: Comparison of Specimens 1, 2 and 3

Figure 14: Flexural Test: Displacement Vs Load.

5.3 Impact Test

The energy absorbed by the each specimen when it is impacted by a heavy blow is summarized in the table 3.

Table 3: Impact Test Results

Specimen No.	Composition	Energy Absorbed in Joules
1	Neem 75%+Areca 25%	1.5
2	Neem 50%+Areca 50%	23
3	Neem 25%+Areca(75%	3.1

5.4 Wear Test

The results of the wear test are tabulated in the table 4. The figure 15 shows the variations of wear rate of composite specimens corresponding to sliding distance. The composite specimen 3 with neem 25 % and areca 75% perform better in comparison with composite specimens 1 and 2 which have lesser areca content. The wear test confirms that the resistance of specimen against wear increases with higher content of areca fiber.

Table 4: Wear Test Results

Specimen	Load (kg)	Speed of Disc (r.p.m)	Time for Sliding (minutes)	Weight before Test(g)	Weight After Test(g)	Loss in Weight (g)	Wear Rate (mm^3/m)
1	0.5	800	5	15.9947	15.9826	0.0121	0.0123
2	0.5	800	5	16.2358	16.2264	0.0094	0.0095
3	0.5	800	5	16.4395	16.4310	0.0085	0.0086

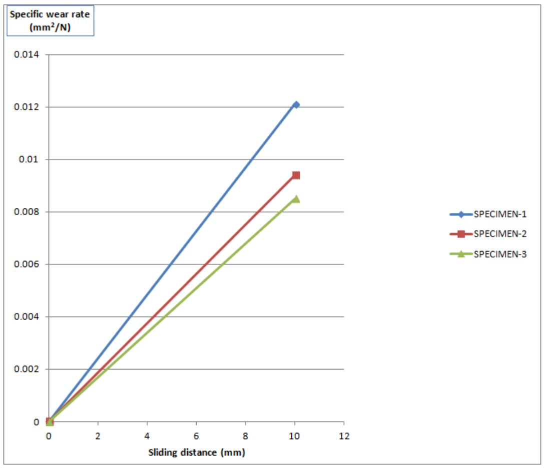


Figure 15: Wear Test-Sliding Distance Vs Wear Rate.

5.4 Result of Morphological Analysis

The figure 16 shows the SEM images of specimens (Neem 75%+Areca 25%) of tensile test. Figures 16a and 16b show the breakage of matrix and crack growth direction. Figure 16c and 16d shows the formation of small debris in the matrix structure.

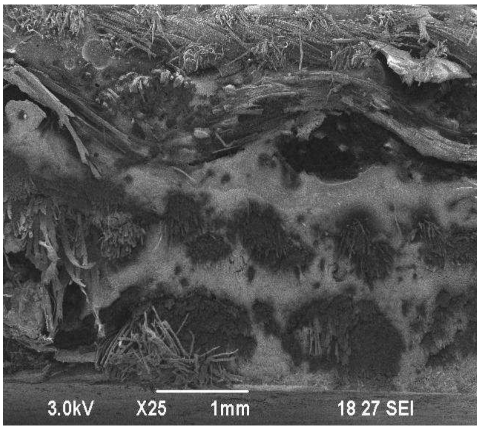


Figure 16 (a)

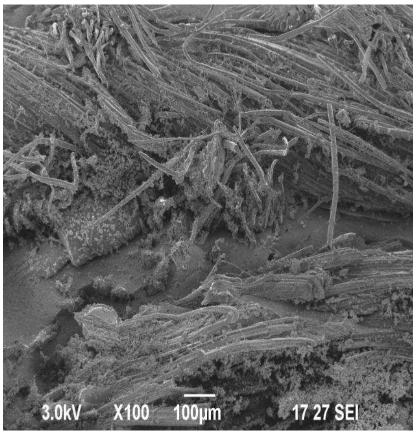


Figure 16 (b)

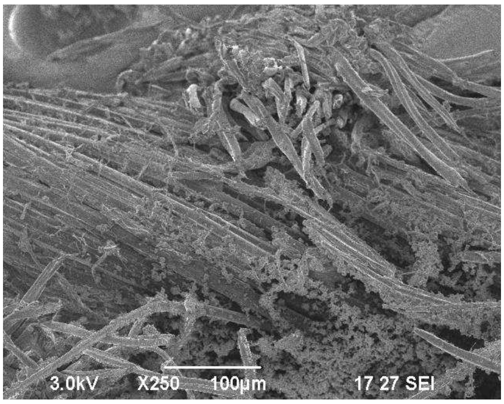


Figure 16(c)

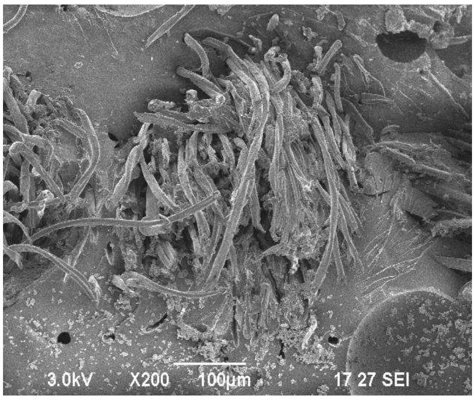


Figure 16(d)

Figure 16: SEM Analysis of Tensile Test Specimen 1 (Neem 75%+Areca 25%).

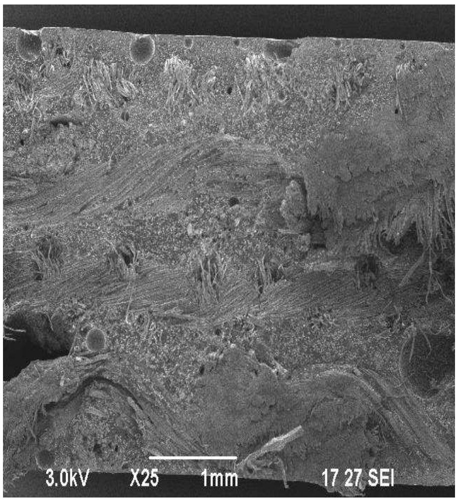


Figure 17 (a)

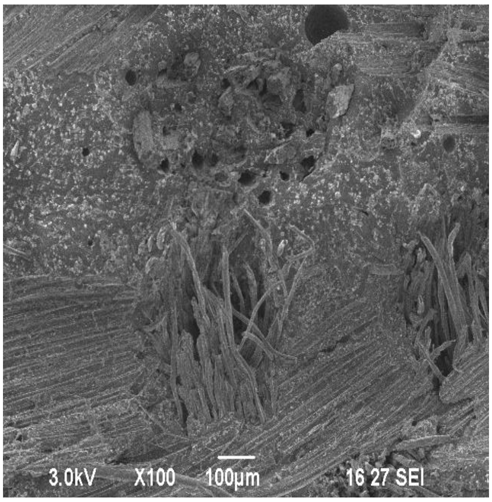


Figure 17 (b)

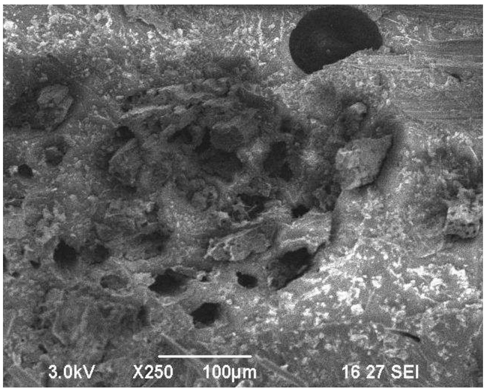


Figure 17 (c)

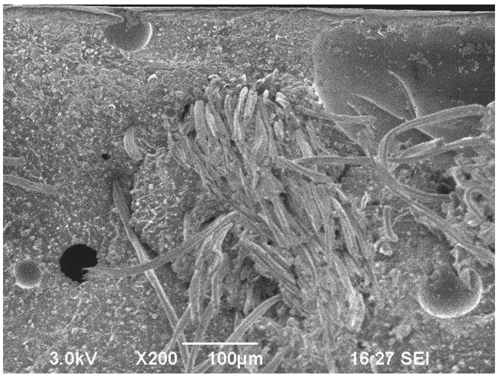


Figure 17 (d)

Figure 17: SEM Analysis of Flexural Test Specimen 2 (Neem 50%+Areca50%).

Figure 17 shows the SEM images of specimens Neem 50%+Areca 50% of flexural test. figure 17 a and 17 b indicates the uneven breakage of fibers and figure 17 c and figure 17 d shows the formation of debris on the surface of the matrix figure 18 shows the SEM images of specimens with 25% neem and 75% areca. It shows the formation of debris from in the composite specimen.

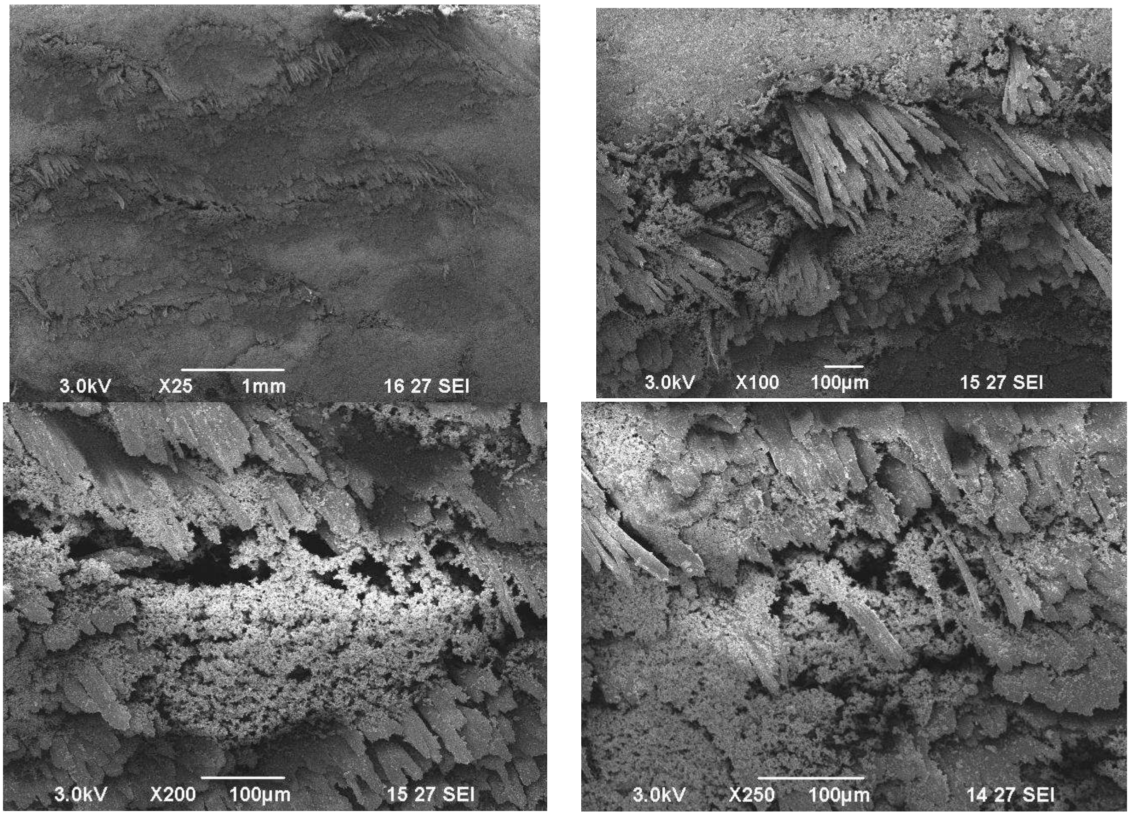


Figure 18: SEM Analysis of Specimen 3 (Neem 25%+Areca 75%).

6. CONCLUSIONS

In this work three types of composites were fabricated with hand-layup method. It was found that among the specimens 1 (Neem 75% + Areca 25%), Specimen 2 (Neem 50% + Areca (50%) and specimen 3 (Neem 25% + Areca (75%), the specimen 3 exhibits good mechanical characteristics. It has better morphological properties and good wear performance. This composite is more suitable for marine application due to the presence of neem.

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